Hydraulics

3rd Year civil

First Term (2009 - 2010)

Chapter ( )

2009 - 2010

Modeling

هى عمليه محاكاه للمنشأت الموجوده بالطبيعه داخل المعامل
وتكون عقيا من أصغر   (مثل ملاكيت)

Advantages of modeling:

١ - اكتشاف عيوب المنشأ قبل الانشاء .

٢ - تقليل تكاليف الانشاء .

٣ - دراسه حالات التحميل المختلفه .

٤ - تستخدم لدراسه الحالات المعقده .

Disadvantages of modeling:

١ - يصعب بعض القوى المؤثره لايمكن تمثيلها معمليا
(نسبة الرطوبه - درجه الحراره - الامطار - ....)

٢ - عمل النماذج مختلف عن الحلول الرياضيه .

٣ - عند استخدام نماذج مشوهه يصعب احتمال الخطأ .

Types of similarity:

أنواع النمذجه

1- geometric similarity:

ومنظر يكون النموذج بنفس نسب الابعاد الموجوده فى
الطبيعه

$$L_r = \frac{L_m}{L_p}$$

Lp : السمبر فى الطول   Lm : الطول فى النموذج

2- _Kinematic Similarity_ :

و فيها يتم نمذجه العجله والسرعه في الطبيعه بعجله وسرعه اخرى في المعمل وكذلك نتعرف

$$V_r = \frac{V_m}{V_p}$$

V_r : النسبه بين سرعه الطبيعه وسرعه المعمل .

V_p : السرعه في الطبيعه .

V_m : السرعه في المعمل .

3 - _Dynamic similarity_ :

و فيها يتم نمذجه القوى الموجوده في الطبيعه متمثلا بقوه اخرى في المعمل . (مثل الضغط - الـ momentum - .....)

$$F_r = \frac{F_m}{F_p}$$

حيث : F_r : النسبه بين القوه الطبيعيه والقوه في المعمل

F_m : القوه في المعمل .

F_p : القوه في الطبيعه .

ملحوظه تتم عمليه النمذجه بناءً على أحد الـ Dimension less parameters التي تم شرحها في ch (1)

وهي (IF ، R ، M ، W)

و سوف نقوم بدراسه النماذج المبنيه على IF ، R

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Modeling depend on RR :

ويُستخدم هذا النوع من النماذج عندما يكون التأثير الأساسي للظواهر معتمداً على لزوجه السائل .

ويتم عمل النماذج به في حالات :

١ - السريان في المواسير .

٢ - انخفاضات ما بين بيانات .

٣ - حركة الغواصات و الأجسام المغمورة في السوائل .

وفي هذه الطريقة يتم جعل RR في الطبيعه = RR في المعمل

$$RR_r = \frac{RR_m}{RR_p} \qquad , \qquad RR = \frac{V.Y}{v}$$

v : خاصيه ثابته

$$\therefore \quad RR_r = 1 = \frac{V_r . L_r}{v_r}$$

$$\therefore \quad \frac{L_r}{T_r} . L_r = 1$$

$$\boxed{\therefore \quad T_r = L_r^2}$$

وفي هذه الحاله يتم استبدال كل زمن وظهور بمربع الطول .

Modeling depend on FF

ويستخدم هذا النوع من النماذج عندما يكون التأثير الأساسي للظواهر مرتبط بقحله لجاذبيه و

ويستخدم في حالات اشتتيه :

١- السريان داخل القنوات .

٢- دراسه المنشآت الهيدروليكيه داخل القنوات .

٣- دراسه حركات الأمواج .

٤- دراسه الظواهر القصيره والكليه مثل (القفزه الهيدروليكيه)

٥- السريان خروجا للصدارات واسفل البوابات .

وفى هذه الطريقه يتم جعل FF فى الطبيعه = FF فى المحل

$$FF_r = \frac{FF_m}{FF_p} \qquad , \qquad FF = \frac{V}{\sqrt{g \cdot y}}$$

$$\therefore FF_r = 1$$

$$\therefore \frac{V_r}{\sqrt{g_r \cdot L_r}} = 1$$

مخبله لجاذبيه ثابته فى المحل و فى الطبيعه

$$\therefore V_r^2 = L_r$$

$$\therefore \frac{L_r^2}{T_r^2} = L_r$$

$$\boxed{T_r = L_r^{1/2}}$$

وفى هذه الحاله يتم استبدال كل زمن بجزر الطول

Types of models

انواع النماذج

1- undistorted models:

نماذج غير مشوهه ويتم فيها استخدام نفس النسب بعيد الابعاد في الطبيعه وللمحل وكذلك استخدام نفس مواد الانشاء الطبيعيه

2- Distorted models:

نماذج مشوهه ويتم فيها استخدام نسب مختلفه لتمثيل الابعاد أو استخدام مواد مختلفه عن المواد الطبيعيه . وتنقسم النماذج المشوهه لنوعين .

Types of distortion:

a - geometric distortion
يحدث اختلاف في النسب المستخدمه بين الاطوال

b - material distortion
وتستخدم فيها مواد مغايره للمستخدمه في الطبيعيه

c - Conveguration distortion.
يتم استخدام سيول معمليه غير موجوده بالطبيعه

8- An 1500 m wide and shallow river has a flow of 3000 m³/s with a velocity of 1.5 m/s. The model is constructed at a horizontal scale and vertical scales of 1/800 and 1/40 respectively. If n in the prototype is 0.025 what would be the Manning's n for the model? Find also, the slope of the model? [Ans. 0.0608, 0.0923]

9- A model of a river is constructed to a horizontal scale of 1/1000 and a vertical scale of 1/100. The river has a discharge of 4000 m3/s and n=0.03. Find the discharge and n of the mode. If the time of travel of flood peak through 100 m in the model is 1 hr, how much time would be flood take to travel the corresponding distance in the river? [Ans. 41 it/s, 0.044, 100 hr]

10- A model boat 1/100 size of its prototype has 0.1 N resistance when simulating a speed of 6 m/s of prototype. In both cases the fluid is water. What is the prototype resistance? Find the speed in the model. [Ans. 10^3 N, 0.6 m/s].

11- It is required to construct a model of a surge tank to study some flow problems in a prototype surge tower. Find the diameter of the tank of the model corresponding to a diameter of 3.5 m in the prototype. if n in the prototype if n is the same in both model and prototype. and the following data are available:

	L'gth, L_m	Pipe dia, d_m	Initial Velocity, V
Model	10	0.18	0.4
Prototype	200	1.8	2.0

12- A model to study bed movement is to be constructed with a horizontal scale of 1/500 and vertical scale 1/125. A large sample of bed load from prototype is tested at a slope of 0.002, in a laboratory tilting flume, begins to have general movement at a depth of flow of 150 mm. The critical tractive force to generate a similar general movement of the sand bed to be

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Problems

1- A 1:20 model of a spillway dissipates 0.25HP. What is the horsepower dissipated by the prototype? [Ans. 8944.3 HP]

2- A ship whose full length is 100 m is to travel at 10 m/s. For dynamic similarity what velocity should a 1:75 model of the ship have in a towing tank? [Ans. 2 m/s].

3- A 1:50 model of an ogee spillway crest records an acceleration of 1.5 m/s² at a certain location. What is the homogenous acceleration of the prototype? [Ans. $a_p=a_m=1.5$ m/s as $a_r=1$]

4- A 1:50 model of an aeroplane is tested in air and the model velocity is 45 m/s. If the model is towed in water of kinematic viscosity $0.01*10^{-4}$ m²/s. ($v_{air}=0.15 *10^{-4}$ m²/s). What will be the corresponding speed in water. Also calculate the prototype drag if the model drag as measured in water is 6N. given that $\gamma_{air}=11.5$ N/m³. [Ans. 180 m/s, 1.58N]

5- A model of linear scale ratio of 1:10 is prepared of a bridge pier 1 m wide. The depth of water in near the pier is 3 m. The velocity and force measured for the model are 0.6 m/s and 6.4 N respectively. Determine (a) the width of pier in the model (b) depth of water in the model (c) velocity of water under the bridge and (d) the force on the bridge pier.

6- A shallow river is 1200 m wide and the maximum depth of flow in it is 4.6 m. It carries a discharge of 2830 m3/s with a velocity of 0.9 m/s. A model of the river is constructed with a horizontal and vertical scales of 1/800 and 1/40 respectively. What will be the roughness n of the model if that of the river bed is 0.25. Find the discharge of the mode. Is the flow in the model laminar or turbulent? Assume μ=1.1 cp and assume the hydraulic mean depth is equal to the depth of flow. [Ans. 0.142 m/s, Turb. Flow, 14 m/s].

7- In a model test of a spillway the discharge and velocity of flow over the model are 2 m³/s and 1.5 m/s respectively. What is the discharge and velocity over the prototype which is 36 times the model size? [Ans. 9 m/s, 15552 m³/s].

Modelling

$Q_{(1)}$:

* $L_r = 1:20$

* $(H.P)_m = 0.25\ hp$

Req.: $(H.P)_p = ?$

Sol.:

$$\therefore (H.P)_r = \frac{(H.P)_m}{(H.P)_p}$$

$$(H.P)_r = \frac{\gamma_r\ Q_r\ H_r}{75 \times \eta} = \gamma_r \cdot Q_r \cdot H_r$$

for the same liquid $\gamma_r = 1$

$$(H.P)_r = Q_r \cdot H_r = \frac{L_r^3}{T_r} \times L_r$$

$$(H.P)_r = \frac{L_r^4}{T_r}$$

for Froude similarity $T_r = L_r^{1/2}$

$$(H \cdot \dot{P})_r = \frac{L_r^4}{L_r^{1/2}} = L_r^{3.5}$$

$$L_r^{3.5} = \frac{(H \cdot \dot{P})_m}{(H \cdot \dot{P})_p}$$

$$\left(\frac{1}{20}\right)^{3.5} = \frac{0.25}{(H \cdot \dot{P})_p}$$

$$(H \cdot \dot{P})_p = 8944.3 \quad h \cdot p \#$$

Q (2):

× $L_p = 100 \, m$, $V_p = 10 \, m/s$

× $L_r = 1:75$, $V_m = ??$

$L_m = ??$

sol..

$$\therefore V_r = \frac{V_m}{V_p} = \frac{L_r}{T_r}$$

for Froude similarity $\quad T_r = L_r^{1/2}$

$$V_r = \frac{L_r}{L_r^{1/2}} = L_r^{1/2}$$

$$L_r^{1/2} = \frac{V_m}{V_p}$$

$$\left(\frac{1}{75}\right)^{1/2} = \frac{V_m}{10}$$

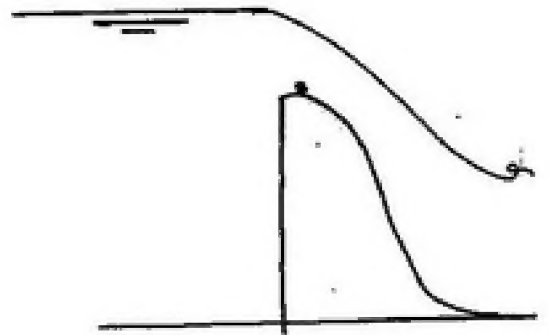$$V_m = 1.15 \ m/s \ \#$$

$$\therefore \ L_r = \frac{L_m}{L_p}$$

$$\frac{1}{75} = \frac{L_m}{100}$$
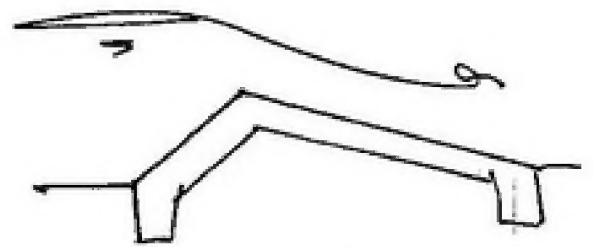
$$L_m = 1.33 \ m \ \#$$

Q(3):

$$* \ L_r = 1:50$$

$$a_m = 1.5 \ m/s^2$$

Req.: $a_p = ??$

sol.: $a_r = \dfrac{a_m}{a_p}$

$$a_r = \frac{L_r}{T_r^2} = \frac{L_r}{(L_r^{1/2})^2} = \frac{L_r}{L_r}$$
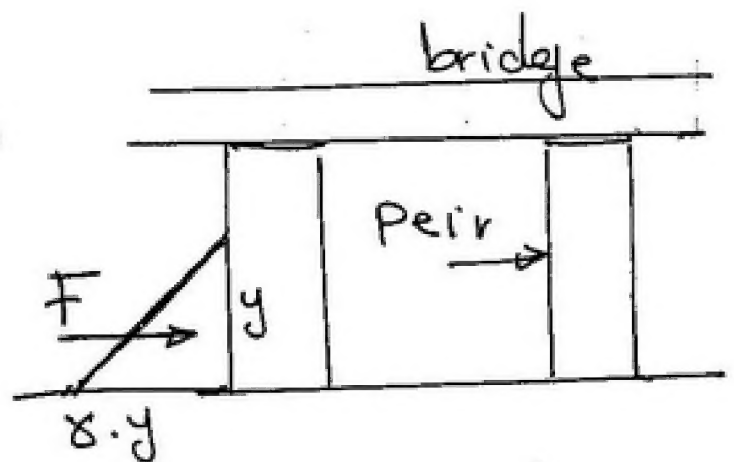
$$a_r = 1$$

$$1 = \frac{a_m}{a_p}$$

$$a_m = a_p = 1.5 \ m/s^2 \ \#$$

$Q_{(S)}$

* $L_r = 1 : 10$

$W_p = 1m$

$Y_{p.} = 3m$

$Y_m = 0.6 \ m/s'$

$F_m = 6.4 \ N$

Req. :

1 - $W_m = ?$

2 - $Y_m = ?$

3 - $V_p = ?$

4 - $F_p = ?$

Sol.:

$$\because \quad W_r = \frac{W_m}{W_P}$$

$$W_r = L_r$$

$$L_r = \frac{W_m}{W_P}$$

$$\frac{1}{10} = \frac{W_m}{1.0} \implies W_m = 0.1m \quad \#$$

$$\because \quad y_r = \frac{y_m}{y_P}$$

$$L_r = \frac{y_m}{y_P}$$

$$\frac{1}{10} = \frac{y_m}{3} \implies y_m = 0.3m \quad \#$$

$$\because \quad V_r = \frac{V_m}{V_P}$$

$$V_r = \frac{L_r}{T_r} = \frac{L_r}{L_r^{1/2}} = L_r^{1/2}$$

$$L_r^{1/2} = \frac{V_m}{V_P}$$

$$\left(\frac{1}{10}\right)^{1/2} = \frac{0.6}{V_P}$$

$$V_P = 1.90 \ m/s \ \#$$

$$\therefore \ F_r = \frac{F_m}{F_P}$$

$$F = \frac{1}{2} \times \delta y \times y = \frac{1}{2} \delta y^2 \ /m^2$$

$$F_r = \frac{1}{2} \underset{1.0}{\delta_r} \cdot y_r^2$$

$$F_r = (L_r)^2$$

$$(L_r)^2 = \frac{F_m}{F_P}$$

$$\left(\frac{1}{10}\right)^2 = \frac{6.4}{F_P}$$

$$F_P = 640 \ N/m \#$$

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Q(7): $Q_m = 2 \ m^3/s$, $V_m = 1.5 \ m/s$

$\qquad\qquad\qquad$; $L_r = 1:36$

Req. $Q_P = ?$ $\qquad$, $\qquad V_P = ??$

$\underline{\underline{Sol..}}$

$\because \quad Q_r = \dfrac{Q_m}{Q_p}$

$Q_r = \dfrac{L_r^3}{T_r} = \dfrac{L_r^3}{L_r^{1/2}} = L_r^{2.5}$

$L_r^{2.5} = \dfrac{Q_m}{Q_p}$

$\left(\dfrac{1}{36}\right)^{2.5} = \dfrac{2}{Q_p}$

$Q_p = 15552 \quad m^3/s' \quad \#$

$\because \quad V_r = \dfrac{V_m}{V_p}$

$V_r = \dfrac{L_r}{T_r} = \dfrac{L_r}{L_r^{1/2}} = L_r^{1/2}$

$\left(\dfrac{1}{36}\right)^{1/2} = \dfrac{1.5}{V_p}$

$V_p = 6 \quad m/s' \quad \#$